

Remarks:

New claims 24 and 25 have been amended. Claims 13-22 were previously cancelled. Accordingly, claims 1-12 and 23-25 are currently pending for consideration.

I. Amendments:

New claim 24 depends from claim 10 and recites that the cathode compartment has an alkali metal hydroxide concentration from about 40 to about 160 g/l. Support for this claim can be found in the specification at page 5, line 8. Accordingly, no new matter has been added.

New claim 25 recites that the gas diffusion electrode is arranged on the separator. Support for this claim can be found in the specification at page 5, lines 36-37. No new matter has been added.

II. The Invention:

The presently claimed invention is directed to a process for producing alkali metal chlorate in an electrolytic cell that is divided by a cation selective separator into an anode compartment in which an anode is arranged and a cathode compartment in which a gas diffusion electrode is arranged. The process comprises introducing an electrolyte solution containing alkali metal chloride into the anode compartment and an oxygen-containing gas into the cathode compartment.

The present invention provides a process for producing alkali metal chlorate which avoids the problems of using alkali metal chromates associated with previously known processes that employ gas diffusion electrodes and avoids the costs and handling problems associated with using considerable amounts of hydrochloric acid and alkali metal hydroxide that are employed in other known processes, while at the same time provides an energy-efficient electrolytic process for the production of alkali metal chlorate and makes a large portion of externally added pH-adjusting chemicals superfluous.

III. Rejections:

Claims 1-5, 7, 9-11 and 23 stand rejected under 35 U.S.C. § 103(a), as being unpatentable over Cook, Jr. (US Pat. No. 3,897,320), in view of Oda et al. (US Pat. No. 4,299,682). The Applicants respectfully traverse.

Cook is directed to the production of chlorates from alkali metal chloride solution in a two compartment cell equipped with an effective cation-active permselective membrane divider with the production of some chlorate in the anolyte and subsequent electrolysis of the anolyte in a chlorate cell (col.1, l.5-13).

Cook states that "an advantage of this invention is that alkali metal chlorate produced by transmission of hydroxide through the membrane into the anolyte is recovered and the anolyte is subsequently utilized as a feed to a chlorate cell (col.1, l.19-23). It is further set out that "because the cation-active permselective membrane 23 allows some hydroxyl ions to migrate through it from the catholyte to the anolyte these can react to produce chlorate in the anolyte" (col.2, l.10-12). Cook further teaches that the cation-active permselective membrane should permit from 5 to 50 percent of the caustic produced in the catholyte compartment to migrate to the anolyte compartment (col.7. l.10-13).

Applicants respectfully submit that the present invention differs from Cook, as acknowledged by the Office Action by defining the use of a gas diffusion electrode and the introduction of oxygen-containing gas. Applicants submit that the present invention is further distinguished by performing the process in a cell divided by a cation selective separator rather than the specific permselective membrane of Cook, which is designed to allow significant transmission of hydroxide through the membrane into the anolyte. Even though the cation selective separator according to the present invention may permit some back migration of hydroxide ions, Applicants respectfully submit that it would only be an inconsiderable amount. This is evidenced in the present specification at p.3, l.9-12, where it is stated that the cation selective separator permits transmission of cations, but is substantially resistant to chlorine and alkali metal hydroxide, i.e., chloride and hydroxide ions. As a result of the different cells, Applicants respectfully

submit that the chorate is formed in the respective anode chambers by different mechanisms.

Although the Office Action acknowledges that Cook does not disclose using a gas diffusion electrode, it contends that it would have been obvious for a person of ordinary skill to do so based on Oda et al because of their teachings that a gas diffusion electrode results in decreased operating voltage. Applicants respectfully disagree.

Oda et al disclose a gas diffusion electrode suitable for use in electrolysis of an alkali metal chloride, e.g. for the production of an alkali metal hydroxide or an electrode in a fuel cell (abstract, col.4, I.22-25). However, Applicants respectfully submit that they are unaware of any disclosure by Oda et al regarding the production of alkali metal chlorate via such an electrode or even the integrated production of chlorine and alkali metal hydroxide for supply thereof to a chlorate cell.

Applicants submit that one of ordinary skill in the art would understand that Oda et al use a conventional "cation selective separator," which allows transmission of cations into the cathode compartment, but is highly resistant to transmission of anions (see col.4, I.30-col.5, I.43). Accordingly, Applicants respectfully submit that one of ordinary skill in the art would have no reason to use the gas electrode of Oda et al in the process of Cook since Oda et al and Cook refer to different processes using different cell designs, and because there would be no reason to expect improved efficiency for the gas electrode in the cell design of Cook, which uses a permselective membrane that permits a significant exchange of anions, e.g., hydroxide ions.

In addition, Applicants respectfully submit that even assuming arguendo that Oda et al and Cook can be properly combined, which Applicants do not concede, using the cell design of Cook with the gas diffusion electrode of Oda et al, would not arrive at the presently claimed invention because of the different cell designs and chemistry between the present invention and Cook.

Therefore, it is respectfully requested that the rejections of claims 1-5, 7, 9-11 and 23 under 35 U.S.C. § 103(a), as being obvious over Cook, in view of Oda et al., be withdrawn.

Claims 1-6, 8, 10-12 and 23 stand rejected under 35 U.S.C. § 103(a), as being unpatentable over Wanngard (US Pat. No. 5,419,818), with evidence from Cook, and in view of Oda et al. The Applicants respectfully traverse.

Wanngard is directed to a process of producing alkali metal chlorate in an energy-efficient manner involving significantly reduced health and environmental hazards making superfluous a large portion of the chemicals added in processes for acidification and alkalization. However, Applicants submit that they are unaware of any disclosure by Wanngard of a cell equipped with a separator that is used to produce the chlorate, as presently claimed. To the contrary, Applicants respectfully submit that Wanngard teaches that the chlorate is produced using a non-divided cell and separate chlorate reactor.

The process comprises electrolysis in chlorate electrolyzers of an aqueous electrolyte containing purified alkali metal chloride after which a partial flow of resulting chlorate electrolyte is electrolyzed in a cell equipped with a separator for providing a catholyte which contains alkali metal hydroxide which (alkali metal hydroxide) is used at least partially in the production of alkali metal chlorate (col.2, l.52-59). The electrolysis in the cell equipped with a separator yields an anolyte and a catholyte having lower and higher pH respectively than the chlorate electrolyte supplied to the separator-equipped cell (col.2, l.67-col.3, l.2).

From fig.1 and col.6, l.9-64 of Wanngard, it is clearly disclosed that salt slurry is used for preparing electrolyte (2) for producing chlorate together with chlorate electrolyte from reaction vessels (5) and mother liquor from the chlorate crystallizer (8) (col.6, l.12-15). The electrolyte is acidified by adding acid anolyte from diaphragm cell (12) (diaphragm being used as separator) before supply to the cells of the chlorate electrolyzer (4) (col.6, l.20-25). The chlorate electrolyte is conducted from chlorate

electrolyzer (4) to reactor (5) where the reaction to form chlorate continues (col.6, I.31-33).

With regard to the above, the chlorate electrolyzer (4) is not a divided cell. Thus, it is submitted that Wanngard teaches the use of a non-divided chlorate electrolyzer (4) and a separate chlorate reactor (5) in which chlorate is being produced. Applicants submit that Wanngard discloses that a partial flow of chlorate electrolyte is withdrawn to the separator-equipped cell for production of chlorine in the anolyte and alkali metal hydroxide in the catholyte (i.e., no chlorate production), in which the resulting electrolytes may be used to change the pH of the chlorate electrolyte.

Applicants respectfully submit that although the divided electrolytic cell (12) is being supplied with alkali metal chlorate electrolyte, it is not producing alkali metal chlorate. Instead, the electrolyte from the divided cell (12) is transferred to a chlorate electrolyzer (4) from which chlorate electrolyte is transferred to a chlorate reactor (5).

With regard to the section in col.3, I.59-68 cited in the office action, chlorine gas generated in the separator-equipped cell (12) is dissolved immediately in the anolyte succeeded by partial hydrolysis to hypochlorous acid which in turn dissociate to hypochlorite (col.4, I.1-5). Accordingly, Applicants respectfully submit that formation of chlorate is thus not described to occur in divided cell (12). Moreover, Applicants submit that they are unaware of any disclosure by Wanngard of a divided chlorate cell (electrolyzer).

Further, it is submitted that a conventional chlorate cell is non-divided, i.e. has no separator between anode and cathode. In that regard, the "Background of the invention" section of Wanngard, at col.1, I.55-61, sets out that "...chloride electrolyte to be electrolyzed in a chlorate cell must not contain high contents of impurities. Thus, Ca^{2+} , Mg^{2+} and SO_4^{2-} (which may be present as impurities in e.g. sodium chloride solutions) give rise to deposits on the cathodes (in the absence of a separator) while heavy metals decompose formed hypochlorite into chloride and oxygen and not into chlorate as desirable" (col.1, I.55-61). Impurities for the chloride electrolyte may thus

reach the cathodes since no ion-selective membrane is hindering transfer of Ca^{2+} , Mg^{2+} and SO_4^{2-} ions in an undivided cell.

Oda et al are also silent on the production of alkali metal chlorate, as well as, on integrated production of chlorine and alkali metal hydroxide for supply thereof to a chlorate cell.

In contrast to the teachings of Wanngard and Oda et al, the presently claimed invention is directed to producing alkali metal chlorate in an electrolytic cell, where chlorate is produced both in the anode compartment of the divided cell and in the chlorate reactor to which the anolyte is transferred.

Applicants submit that one skilled in the relevant art would find no reason to modify the teachings of Wanngard in such a way that the instant process is arrived at, since Wanngard is not aiming at providing a divided chlorate cell, particularly not a divided chlorate cell equipped with a gas diffusion electrode, and actually teaches away from such a cell by teaching the use of a non-divided cell and separate chlorate reactor. In that regard, Wanngard discloses and teaches an integrated production of acid and alkali metal hydroxide in a conventional undivided cell, but using a portion of the chlorate electrolyte for production of acid anolyte and alkali metal hydroxide in the catholyte of a divided chloralkali cell.

It is respectfully submitted that a skilled person could thus not foresee that a divided chlorate cell would advantageously contribute to produce integrally acid and alkali metal hydroxide, based on the teachings of the cited references. On the contrary, Applicants submit that, since several parameters differ between divided and undivided chlorate cells including, e.g., mixing conditions of electrolyte, control of pH, need of supplying acid/hydroxide, the skilled person would have no reason to search for the solution (arrived at in the presently claimed invention) in technology describing divided cells, particularly not the Oda et al. reference, which is silent on integrated production of acid and alkali metal hydroxide and production of chlorate.

Moreover, Wanngard teaches that both the anode and cathode compartments, of the cell containing a separator (12), are charged with chlorate electrolyte containing significant amounts of chlorate (see col. 6, I.31-34). If such a divided cell included a gas diffusion electrode according to Oda et al in the cathode chamber, the chlorate ions in the cathode chamber would result in side reactions that would lead to poisoning of the gas diffusion electrode and make it inoperable. See, for example, the discussion in the instant specification at p.1, I.26-33.

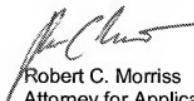
Accordingly, Applicants respectfully submit that neither Wanngard nor Oda et al., when taken alone or together, disclose, teach or suggest the presently claimed invention.

Therefore, it is respectfully requested that the rejections of claims 1-12 and 23 under 35 U.S.C. § 103(a), as being obvious over Wanngard, as purportedly evidenced by Cook, in view of Oda et al., be withdrawn.

Conclusion:

In light of the foregoing, Applicants respectfully submit that the application as amended is now in proper form for allowance, which action is earnestly solicited. If the Examiner has any questions relating to this Amendment or to this application in general, it is respectfully requested that the Examiner contact Applicants' undersigned attorney at the telephone number provided below.

Respectfully submitted,



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